



National Aeronautics and Space Administration

# **Creation and Assessment of Functional Foods for Long-Duration Space Missions**

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# **Functional foods should be considered in long-duration mission planning.**

- The physiological impact of space travel on humans will likely be exacerbated on long-duration missions without countermeasures.
  - Bone mineral density loss, muscle atrophy, space radiation impacts, reduced immune function, eye health, psychological stress
- “Direct reuse and repurposing of logistical items to avoid flying separate items to meet both functions” – Broyan et. al. 2014 on Advanced Exploration Systems Logistics Reduction and Repurposing (LRR) approaches
- By definition, functional foods move beyond necessity to provide additional health benefits that may reduce disease risk and/or promote optimal health.

# Key Questions on Functional Food Implementation

- Which compounds have supporting evidence to indicate functionality?
- Are these compounds stable in space food?
- Can we develop foods with these compounds that also meet the other requirements for space food (microbial safety, high sensory acceptability, nutritional stability, multi-year shelf life, minimal free liquid or crumbing)?

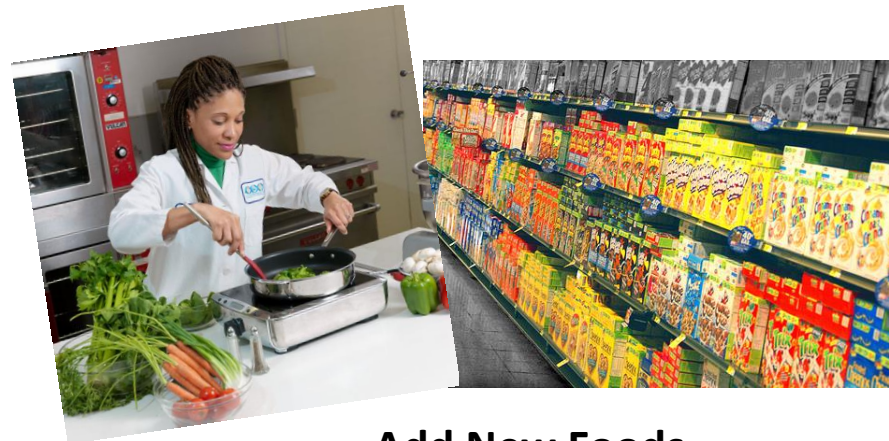


# Study Design

- Selection of bioactive compounds:
  - Lycopene (cancer and CVD prevention, bone health)
  - Lutein (eye health)
  - Flavonoids (reduction of risk of chronic diseases, bone health)
  - Sterols (cholesterol reduction)
  - Omega-3 fatty acids (CVD prevention, bone health)
  - Total phenolics (reduction of risk of cancer, diabetes, and CVD)



**Current Food System**



**Add New Foods**



# Study Status

3 years of 5-year study complete

Analysis includes:

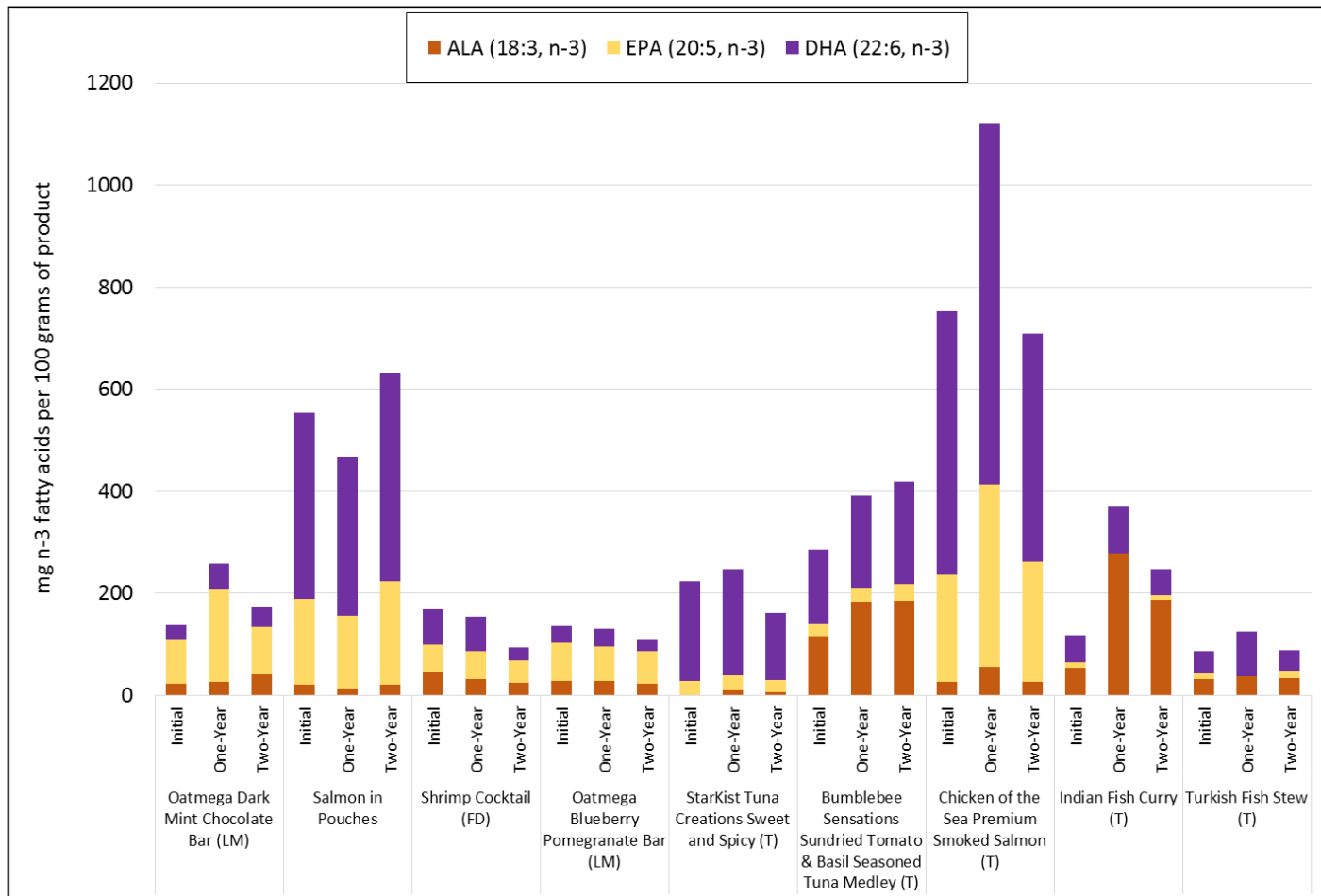
- 15 ISS provisioning food items
- 12 commercial foods
- 18 developed foods

	% Complete					
	Development	Initial Analysis	1-yr Storage		2-Year Storage	
ISS Foods						
Commercial Items						
Developed Foods			61%		28%	

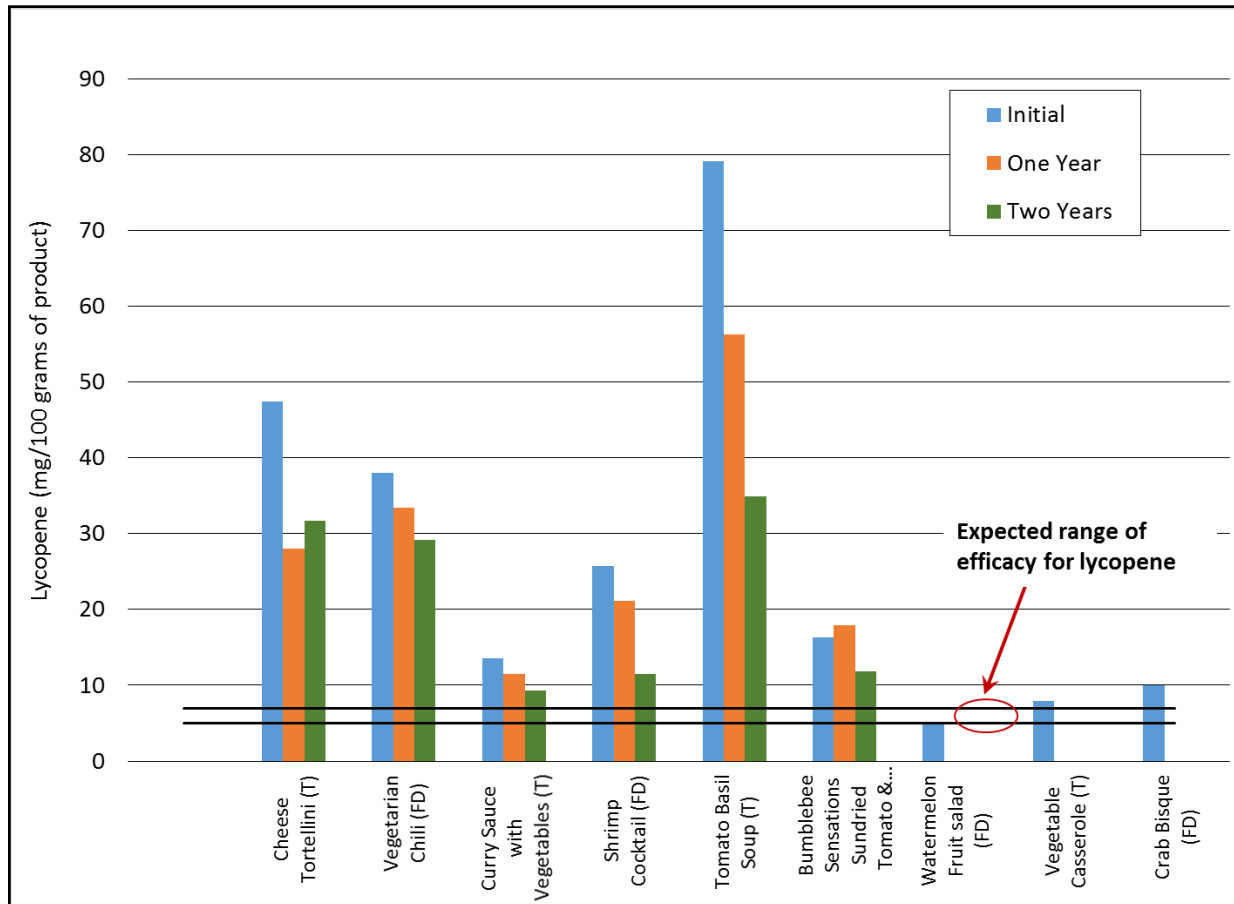


# RESULTS TO DATE

# Fish-derived omega-3 fatty acids are stable at ambient temperatures in processed foods.

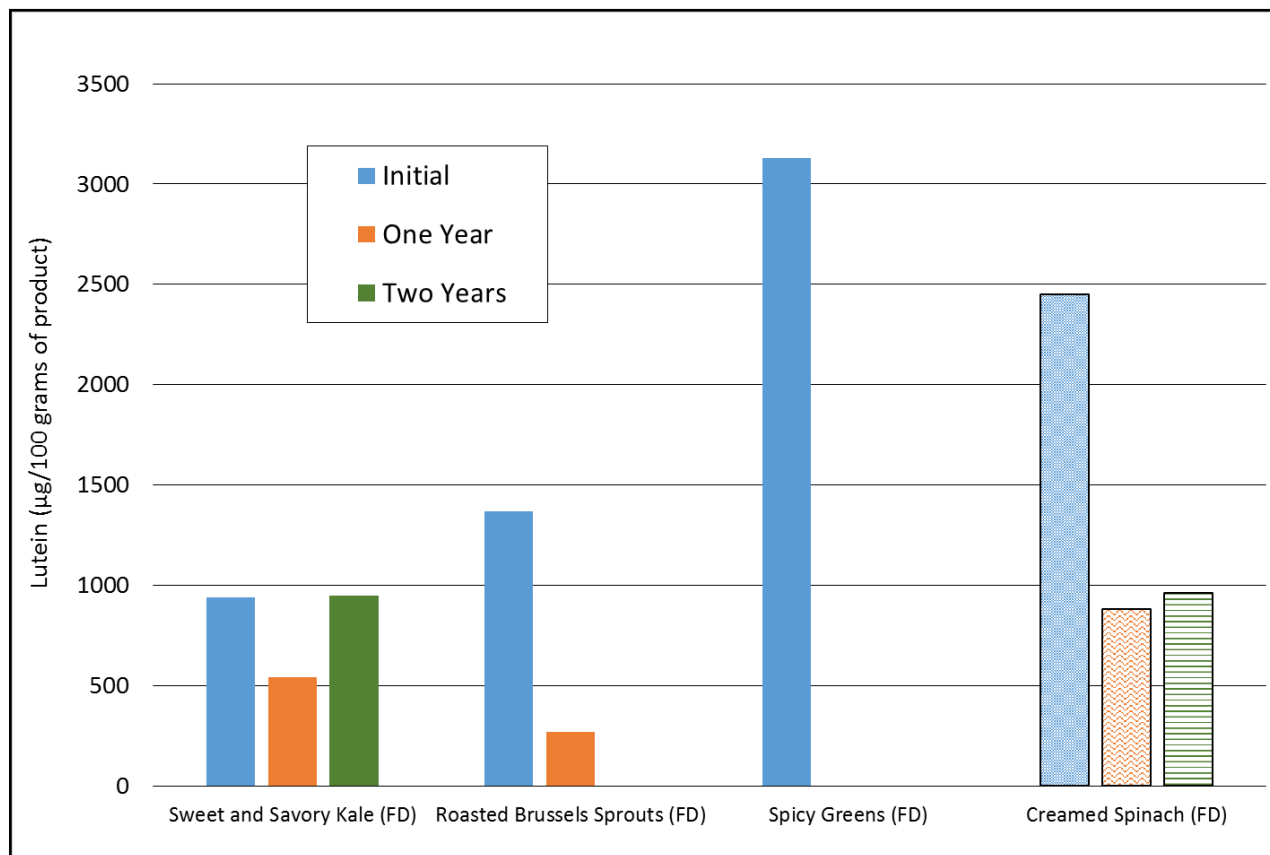


# Lycopene concentrations decline at 21°C yet adequate lycopene remains at beneficial amounts for 2 years.

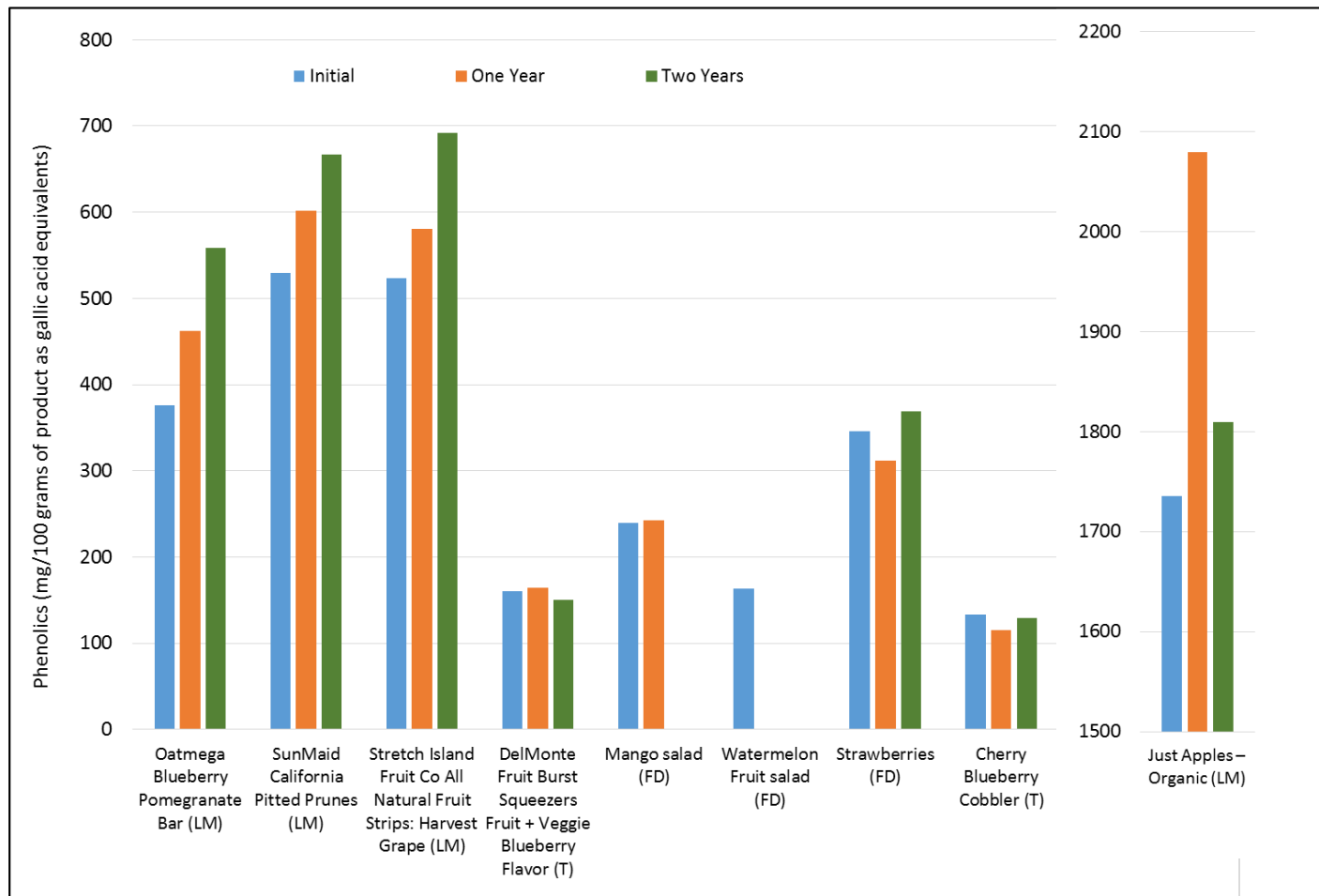




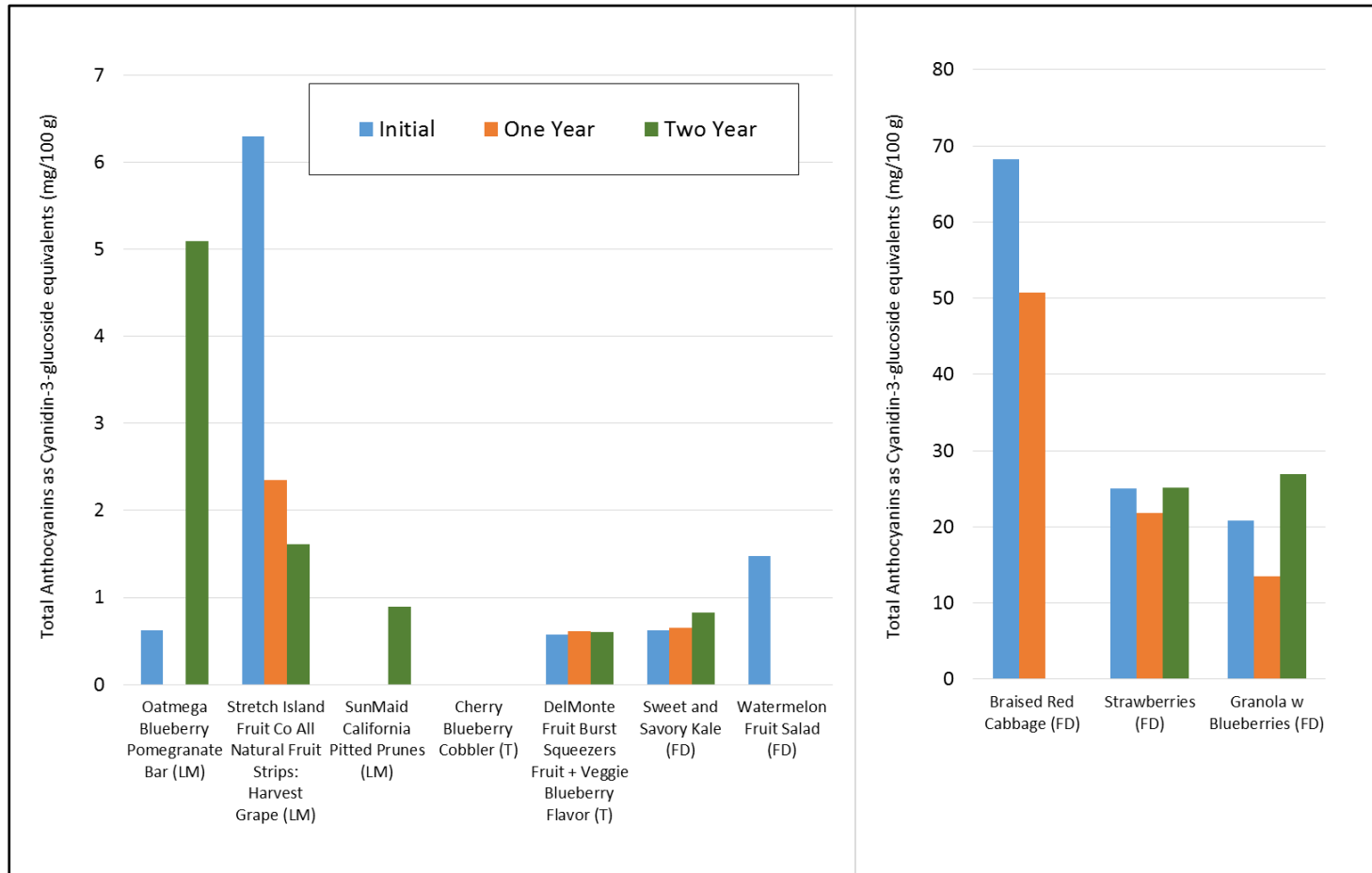
**The evidence does not support lutein stability at 21°C storage nor that 6 mg lutein per day is easily delivered in one serving of FD vegetables.**



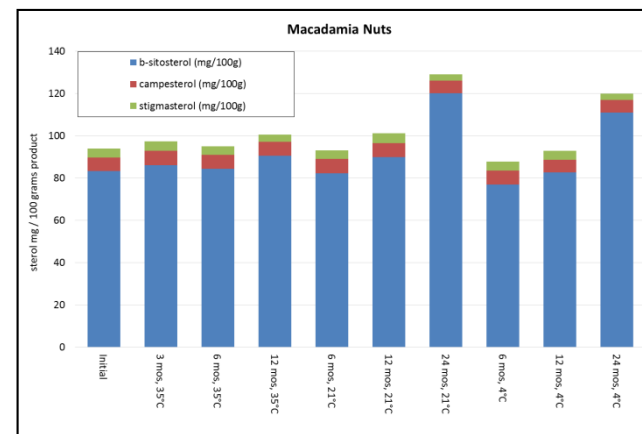
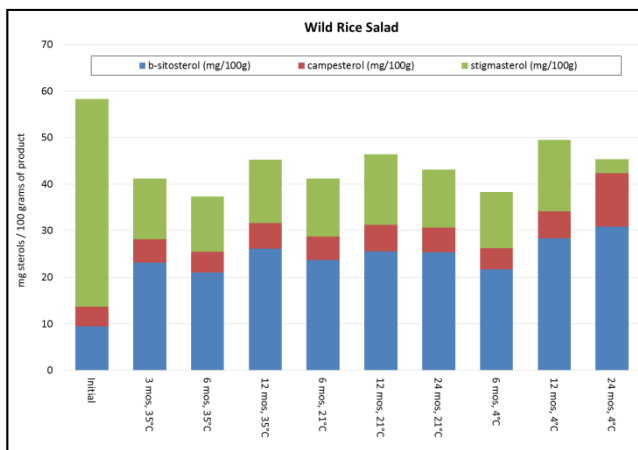
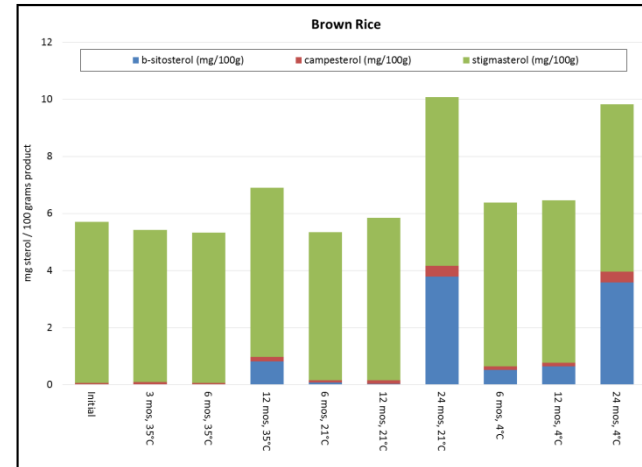
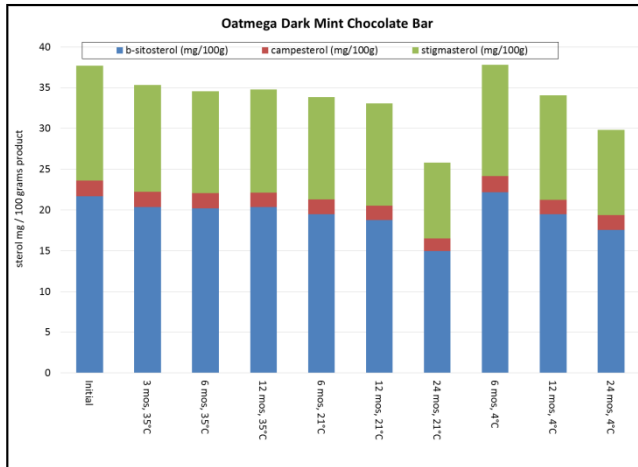
# Total phenolics in fruit samples appeared to increase or remain stable over the storage period.



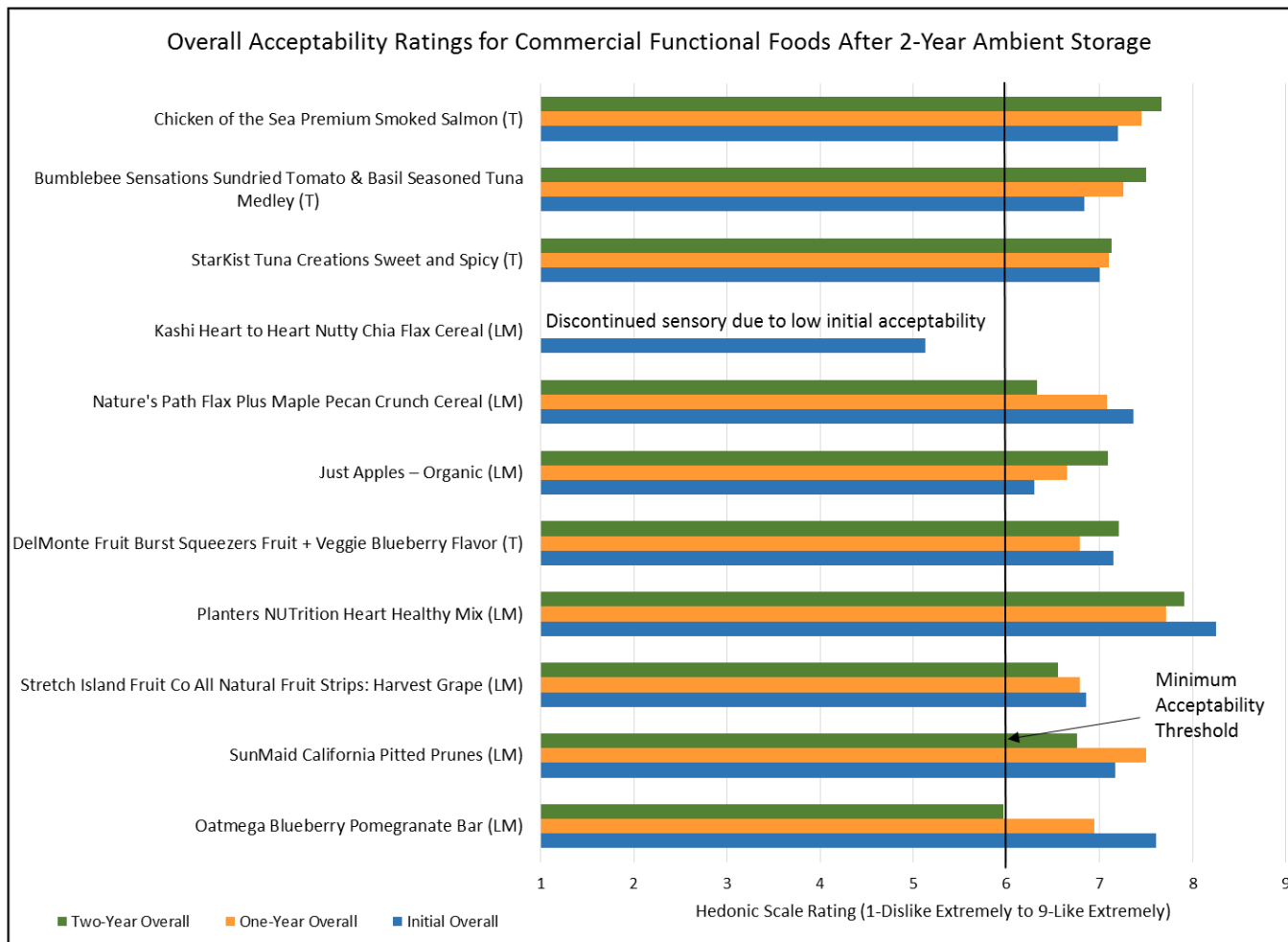
**Detection of total anthocyanins was quite variable;  
stability may be tied to the food matrix.**



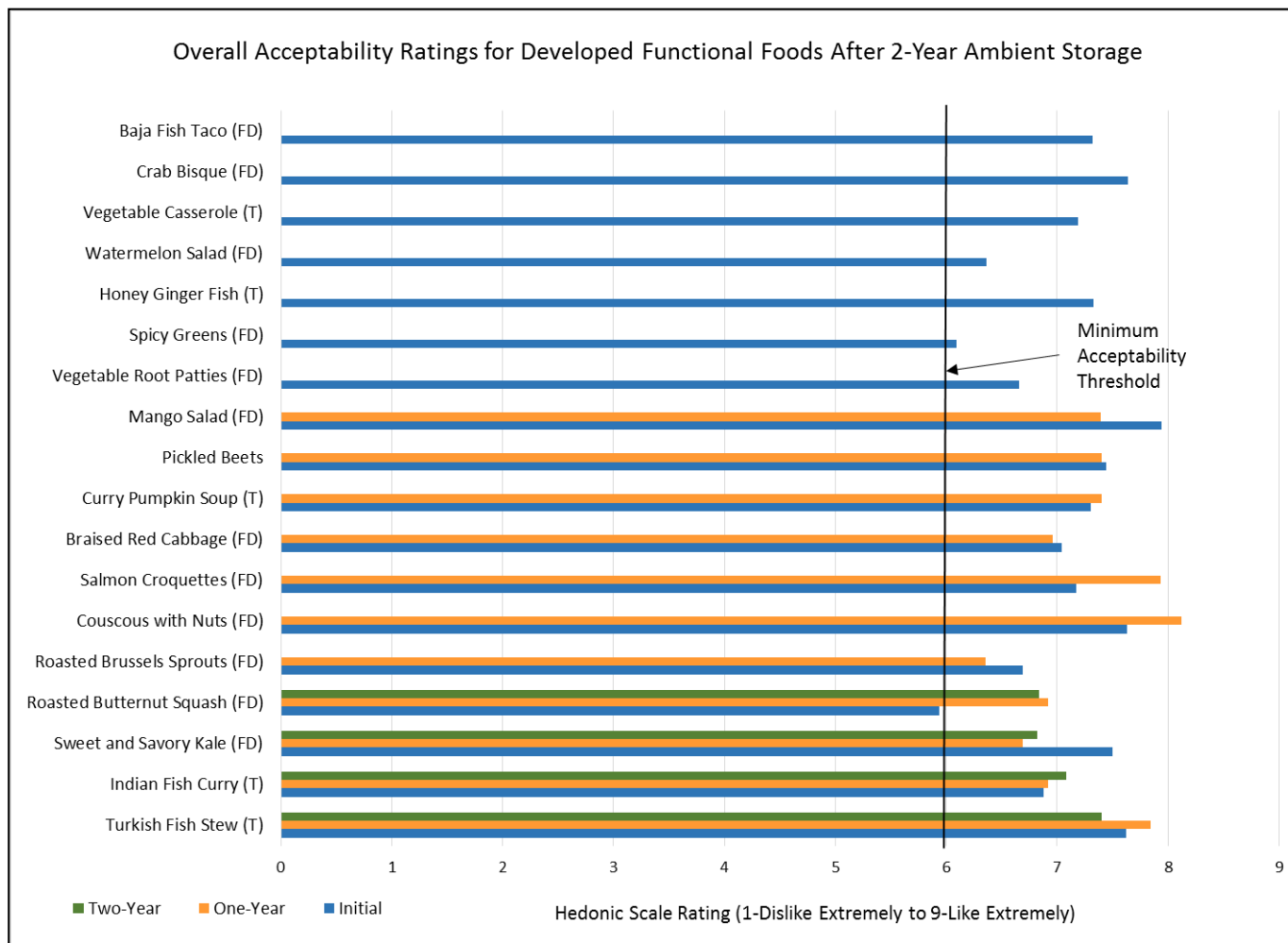
# Sterols are stable across time and storage temperatures in processed foods.



# Sensory Results – Commercial Foods



# Sensory Results – Developed Foods





## Study Implications

- Functional foods that can be incorporated into the space food system through multiple menu servings each day will likely be required for beneficial levels of lutein, sterols, and total phenolics.
- Additions of functional foods can result from either commercial food application or product development with similar results in product stability and flavor acceptability. Very specific applications and extended shelf life needs tend to favor product development.
- Reduced-temperature storage should be considered to retard the degradation of carotenoids and anthocyanins in storage.



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